factors would be accorded to irrigation, or the diversion to cultivated fields of waters which would otherwise flow unimpeded to the lake. I understand that the area of irrigated land within the drainage district of the lake has been greatly enlarged during the last decade, and I do not see how this could fail to influence that balance between inflow and evaporation which determines the height of the lake. The water spread upon the farm lands is in part evaporated directly, and in part transpired by plants, and both these parts are carried away by the air. A portion also finds its way into the ground, and eventually reaches the lake through springs. That which enters the air increases the local relative humidity, and doubtless increases precipitation on the great mountain range to the eastward, so that a portion of it is returned to the rivers, but as the period of principal evaporation and transpiration from the land does not correspond with the period of principal precipitation on the mountains, it is probable that the share of irrigation water thus prevented from escaping the drainage basin is not great. It certainly is not sufficient to prevent the work of irrigation from greatly diminishing the amount of water which the rivers discharge to the lake.

In the natural condition of the country, before the advent of the white man, the rise and fall of the lake was a climatic index responding to the conjoined influences of variations in temperature, precipitation, and wind. Had the gage record been then kept it would have constituted a valuable contribution to the history of climate. But the same immigration, which instituted observations of lake changes, also established various industries tending to modify the condition of the land and interfere with the reaction of natural agencies, and now that agriculture is striving to divert to its own purposes as much as possible of the normal tribute of the lake, the gage has practically lost its value as a register of climate. Much interest, both economic and scientific, still attaches to its readings, and part of that interest is meteorologic, but it has become practically impossible to discriminate between the consequences of natural and human influences.

FOG STUDIES ON MOUNT TAMALPAIS: NUMBER 3—PHOTOGRAPHS OF FOG BILLOWS.

By ALEXANDER G. MCADIE, Forecast Official.

In several papers presented to the Royal Academy of Sciences of Prussia Prof. H. von Helmholtz has discussed the conditions which must occur in the atmosphere where strata of different densities lie close together, with particular reference to the billow and wave effects near the limiting surfaces of the strata.

It appears to me not doubtful,[1] says Helmholtz, that such systems of waves occur with remarkable frequency at the bounding surfaces of strata of air of different densities, even although in most cases they remain invisible to us. Evidently we see them only when the lowest stratum is so nearly saturated with aqueous vapor that the summit of the wave, within which the pressure is less, begins to form a haze.

It is probable, as Helmholtz states, that conditions favorable for the origin and propagation of air waves often exist, but with the exception of certain cloud forms it is seldom that the meteorologist has an opportunity to see this wave action clearly defined. It therefore seems of importance to present a few photographs showing the actual wave effects produced probably by the sharp contrasts of air currents of different densities in the vicinity of Mount Tamalpais. In the preceding papers[2] the contour of the land and the character of the strong indraft of water vapor having a mean temperature of about 12° C., and which is suddenly injected into a mass of air having a mean temperature of about 24° C., have been described in detail.

It is thought that in the photographs of fog billows (Plates I and II) there is evidence of the movement of rectilinear waves propagated with little change of form and velocity along the bounding surfaces of the different air strata.

With a wind velocity of 10 meters per second, which nearly corresponds with the mean velocity of the inflowing colder current (the average summer afternoon velocity of the wind through the Golden Gate is about 22 miles per hour), the wave length, λ, is determined by von Helmholtz to be about 900 meters (2,950 feet). The wave lengths shown in the various fog photographs herewith are of corresponding magnitude and vary, it is estimated, from 100 to 2,000 meters. Helmholtz states further:[3]

Since the moderate winds that occur on the surface of the earth often cause water waves of a meter in length, therefore the same winds acting upon strata of air of 10 degrees difference in temperature maintain waves of from 2 to 5 kilometers in length.

Equations for the velocity of propagation and the diminution of the speed with a change of the depth of the lower stratum and a discussion of the energy of the waves are given for special cases. It is also pointed out that the elevations of the air waves can amount to many hundred meters, and that precipitation could thus be mechanically brought about. The same wind can excite waves of different lengths and velocities, and the interference and reinforcement may perceptibly modify the wave form. One of the processes by which waves of great height can be formed is thus pointed out by Helmholtz, namely, where two wave summits of different groups of waves reinforce each other. The wave height may be so great that foaming is produced. Such long and deep waves may have a bearing on the explanation of certain local and nonperiodic disturbances.

The demonstrated existence of these air billows and waves is important also in connection with the transmission of other air waves. It is well known that sound waves are reflected and refracted in a marked degree in the vicinity of fog banks, fog walls, and fog billows. The inaudibility of fog signals from sirens is one of the greatest sources of danger and anxiety in navigation. Any increase in our knowledge of the dispersion and aberration of these fog signals will be hailed with joy by many thousand travelers. In the vicinity of San Francisco, as evidenced by the series of photographs accompanying these papers, the opportunities for studying the general aberration of sound waves in fog are excellent. It is our earnest hope that in due time some experimental work in this direction may be undertaken at the observatory on Mt. Tamalpais. Some very strange effects have already been noticed with regard to the noise of a train when traversing different air strata.

Zones of audibility appear to be quite sharply marked, even after making allowance for the many canyons and "mesas" (tablelands). On foggy days these zones are greatly modified. In addition to changes in density and temperature which sound waves would experience, there are changes due to the movement of the sound conveying medium. The strong air currents moving toward the listener increase the frequency of vibration, and raise the pitch; conversely the air currents moving away from the listener flatten the note.

There have been several instances on nights without fog where ordinary sounds have been heard distinctly a distance of nearly two miles. On other occasions it has been possible to obtain echoes from hills distant one-half mile or more when the intervening valley was covered with fog. The echoes could not be heard when the fog was absent.

The accompanying photographs may throw light upon the

[1] See Abbe's Mechanics of the Earth's Atmosphere, p. 94.

[2] See MONTHLY WEATHER REVIEW, August, 1900, p. 283, and November, 1900, p. 492.

[3] See Mechanics of the Earth's Atmosphere, p. 103.

much-discussed question of the abnormal aberration of fog signals. It will be remembered that Prof. Joseph Henry, who for twelve years served as chairman of the Lighthouse Board, thought that the wind played a more important part in the abnormal aberration of sound waves than the so-called acoustic clouds described by Professor Tyndall. It is probable that up to a certain point both explanations may hold, but the wind is seemingly the more active factor in most cases. Sound moving with the wind is refracted downward, and moving against the wind refracted upward.[4]

From the great mass of conflicting evidence it appears that a homogeneous atmosphere without the internal stream lines (see reference to this under Air Drainage in previous papers[5]), conveys sound waves very well. But this is not the usual condition. Under normal conditions the mass of air within a mile or two of a lighthouse and extending upward half a mile is neither still nor homogeneous. One of the main purposes of the accompanying fog photographs is to show the stratification, faulting, and upheaval effects, due to differences of temperature and density caused by extensive and rapidly moving currents. Of course the aberration of audibility of fog signals due to changes of the sound-conveying medium is not to be confounded with the aberration in audibility due to topographical features and the normal reflection and refraction of sound waves. Probably within a short distance of every lighthouse there are zones or points of inaudibility due to the latter causes. An excellent illustration of this can be found in a paper on Fogs and Fog Signals of the Pacific coast by Ferdinand Lee Clarke.[6] It is there shown that the sirens around the Golden Gate and in San Francisco Bay are inaudible at certain points. Here there is an interference of sound waves due to numerous natural reflections. It has been suggested that if the fog signals at Lime Point and at Point Bonita were properly attuned a resulting harmonic might be heard at certain points instead of the weakened noise now heard. We need measurements of the energy producing the air pulsation, the proportionate energy reaching the ship or given point, and the rate of expenditure with different conditions of density and air movement. By the employment of suitable resonators the pulsations reaching the ship might be more easily detected. With the introduction of wireless telegraphy, it would almost seem practicable to obtain by this same principle of resonance etherial electromagnetic signals, and by comparing the time intervals between these and the sound waves in air or transmitted through water, the distance apart of the vessels or the distance from the shore might be determined within a few feet.

NOTES BY THE EDITOR.

THE MILWAUKEE CONVENTION OF WEATHER BUREAU OFFICIALS.

After collecting the opinions of a large number of Weather Bureau officials and giving due weight to the inducements offered by local authorities, the Chief of Bureau has concluded that it will be wisest to recommend that the second general convention of Weather Bureau officials be held in Milwaukee late in August or early in September, 1901. In accordance with this recommendation the Honorable Secretary of Agriculture has approved of the proposed convention and has authorized the acceptance of the proffered hospitality of that city. The headquarters of the convention will be at the Hotel Pfister. The freedom of the Milwaukee Press Club is offered to the members of the convention by its President, Mr. W. A. Bowdish. Mr. W. M. Wilson, Section Director at Milwaukee, states that an informal reception and a banquet will be given by the citizens through the Press Club. Those who desire to visit the Pan-American Exposition at Buffalo will, undoubtedly find special inducements in the way of excursion tickets ready at hand. It is probable that three days, viz, Tuesday, Wednesday, and Thursday of the last week in August, or the same days of the succeeding week, but preferably the former, will be sufficient in which to transact the business and pleasures of the convention. Sessions will be held in the morning and afternoon, but not at night. It is hoped that about one hundred officials will be present.

STATION LIBRARIES.

By direction of the Chief of the Bureau, about one hundred selected stations have lately been supplied with the following books: Irrigation and Drainage, by F. H. King. Light, Visible and Invisible, by S. P. Thompson. College Algebra, by E. A. Bowser. Elements of Physics, by Henry Crew. Matter and Motion, by J. Clerk Maxwell. A Students' Standard Dictionnay (abridged from Funk & Wagnalls' Standard). English Grammar, by William Cobbett. Realm of Nature, by H. R. Mill. Elements of Plane and Spherical Trigonometry, by C. W. Crockett. New Astronomy, by D. P. Todd. Text-book of Physics, by W. Watson.

In addition to these, most of the stations had already been provided with the meteorologies of Loomis, Waldo, Buchan, and Scott, Greeley's American Weather, Pope's Electric Telegraph, Abercromby's Principles of Forecasting, Ley's Study and Forecast of Weather, and Rosser's Law of Storms. The section centers of the Climate and Crop Service have also the agricultural works by Storer and Johnson.

Most of the stations also have all the Weather Bureau publications, MONTHLY WEATHER REVIEWS, Bulletins Professional Papers, Annual Reports, Ferrel's Recent Advances in Meteorology, Abbe's Meteorological Apparatus and Methods, Bigelow's Report on International Cloud Observations, Marvin's various Instructions for the use of Instruments and Psychrometric Tables, etc. Those who desire to consult works on meteorology will, therefore, do well to visit the nearest Weather Bureau station.

LECTURES AND INSTRUCTION BY WEATHER BUREAU MEN.

Mr. P. H. Smyth, Observer Weather Bureau, at Cairo, Ill., reports, under date of January 20 that the students of the Douglas School, W. T. Phelps, Principal, are studying the daily weather maps and the work of the Weather Bureau. In addition to the regular instruction, lectures are delivered by Mr. Smyth.

Mr. Alfred F. Sims, Local Forecast Official, Albany, N. Y., lectured on meteorology at the State Normal College, January 28, and before a popular audience on January 25. The latter lecture was finely illustrated with about forty lantern

[4] Consult article, Sound Signals, by Arnold B. Johnson, Chief Clerk, Lighthouse Board, Appleton's Annual Cyclopedia, 1883, p. 719.

[5] See MONTHLY WEATHER REVIEW, November, 1900, p. 492.

[6] Published in 1888 in San Francisco.

Plate I.

Fog Studies. Fog Lifting. View from U. S. Weather Bureau Observatory, Mount Tamalpais, Cal.

Plate II.

Fog Studies. Helmholtzian Fog Billow. View from U. S. Weather Bureau Observatory, Mount Tamalpais, Cal.